1.1.1.1.1.6 Chapter

7

7. Navigation and Position Determination

Navigation is the process of continuously determining your position so you can get from one place to another. By correctly using various navigational techniques, you can efficiently proceed from one point to the next while keeping off-course maneuvering, elapsed time, and fuel consumption to a minimum. Navigation and position determination is critical to the CAP mission. It doesn't do much good to find your search objective if you don't know where you are when you do. This chapter will cover the basic tools of navigation, navigational techniques, and the use of navigational aids (navaids) and instruments.

7.1 Navigation Terms

In order to effectively communicate with the pilot and ground teams, the mission observer must have a clear understanding of various terms that are used frequently when flying aboard CAP aircraft. These are not peculiar to search and rescue, but are used by all civilian and military aviators.

*Course - T*he planned or actual path of the aircraft over the ground. The course can be either *true course* or *magnetic course* depending upon whether it is measured by referencing true north or magnetic north. The magnetic north pole is *not* located at the true north pole on the actual axis of rotation, so there is usually a difference between true course and magnetic course.

Pilots use meridians of longitude to measure a true course on a map, and all of these meridians point to the true north pole. However the aircraft compass can only point at the magnetic north pole. Once you measure true course on the chart, you must apply *magnetic variation* to the true course to determine the magnetic direction you must fly in order to follow the true course. East magnetic variation is subtracted from measured true courses and west variation is added.

You can find magnetic variation factors in several places, and you will learn more about this in the section concerning charts. Magnetic variation factors also take into account abnormalities in the earth's magnetic field due to the uneven distribution of iron ore and other minerals.

Heading - The direction the aircraft is physically pointed. Airplanes don't always fly exactly in the direction they're pointed due to the effect of the wind. True headings are based on the true north pole, and magnetic headings are based on the magnetic north pole. Most airplane compasses can only reference magnetic north without resorting to advanced techniques or equipment, so headings are almost always magnetic.

Drift, or Drift Effect - The effect the wind has on an aircraft. The air mass an aircraft flies through rarely stands still. If you try to cross a river in a boat by pointing the bow straight across the river and maintaining that heading all the way across, you will impact the river bank downstream of your initial aim point due to the effect of the river current. In an aircraft, any wind that is not from directly in the front or rear of the aircraft has a similar affect.

Drift Correction - A number of degrees added to or subtracted from the aircraft heading intended to negate drift or drift effect. In the rowboat example, if you had aimed at a point upstream of the intended destination, you would have crossed in a straighter line. The <u>angle</u> between the intended impact point and the upstream aim point is analogous to drift correction.

Nautical mile - Distances in air navigation are usually measured in *nautical miles,* not statute miles. A nautical mile is about 6076 feet (sometimes rounded to 6080 ft.), compared to 5280 feet for the statute mile. Most experienced aviators simply refer to a nautical mile as a mile. Observers should remain aware of this difference when communicating with ground search teams because most ground or surface distances are measured using statute miles or kilometers. To convert nautical miles into statute miles, multiply nautical miles by 1.15. To find kilometers, multiply nautical miles by 1.85. Also, one nautical mile is equal to one minute of latitude measured along any meridian of longitude. This provides a convenient scale for measuring distances on any chart. Nautical miles are abbreviated "nm".

Knots - The number of nautical miles flown in one hour. Almost all airspeed indicators measure speed in terms of knots, not miles per hour. At one hundred knots an aircraft would fly one hundred nautical miles in one hour in a no wind condition. Some aircraft have airspeed indicators that measure speed in statute miles per hour, and the observer should be alert to this when planning. Knots can be used to measure both *airspeed* and *ground speed*. The air mass rarely stands still, and any headwind or tailwind will result in a difference between the aircraft's airspeed and ground speed. If you fly eastward at 100 knots airspeed, with the wind blowing from the west at 15 knots, your speed over the ground would be 115 knots. If you fly westbound into the wind, your speed over the ground drops to 85 knots. The abbreviation for knots is "kts".

7.2 Latitude and longitude

A system using imaginary reference lines has been developed to locate positions on the earth. These lines are known as parallels of latitude and meridians of longitude. The numbers representing a position in terms of latitude and longitude are known as the coordinates of that position. Refer to Figure 7-1.

You must have a thorough understanding of this coordinate system. It is used on all of our missions and it is the basis for the aircraft's Global Positioning System (GPS) unit, which is our primary means of navigation and position determination.

7.2.1 Latitude

The equator is a great circle midway between the poles. Its plane is perpendicular to a line connecting the poles. Parallel with the equator are lines of latitude. Each of these parallel lines is a small circle, and each has a definitive location. The location of the latitude is determined by figuring the angle at the center of the earth between the latitude and the equator.

The equator is latitude 0 degrees, and the poles are located at 90 degrees latitude. Since there are two latitudes with the same number (e.g., two 45-degree or two 30-

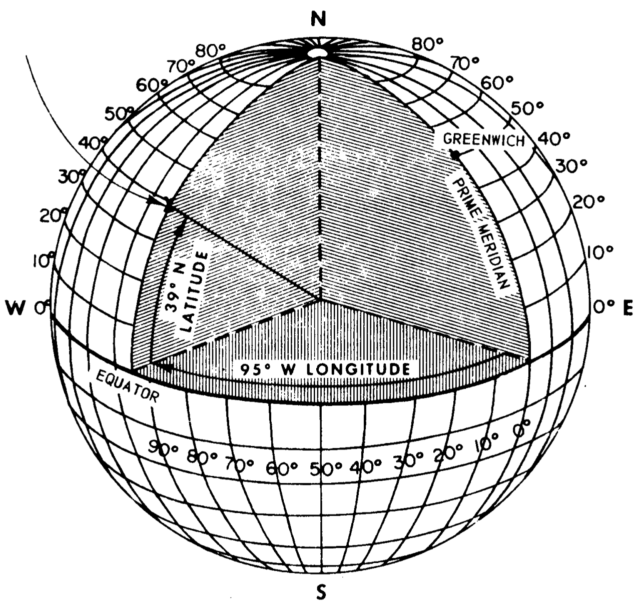


Figure 7-1

degree latitudes), the letter designators N and S are used to show which latitude is meant. The North Pole is 90 degrees north of the equator and the South Pole is 90 degrees south. Thus the areas between the poles and the equator are known as the northern and southern hemispheres.

7.2.2 Longitude

We have seen how the north-south measurement of positions is figured. With only latitude, it is still impossible to locate a point. This difficulty is resolved by use of longitude, which indicates east-west location.

There is no natural starting point for numbering longitude. Therefore the solution was to select an arbitrary starting point. When the natives of England began to make charts they chose the meridian through their principal observatory in Greenwich, England, as the zero line. This line has been adopted by most other countries of the world. The Greenwich meridian is sometimes called the first, or prime, meridian. Actually, it is the zero meridian.

Longitude is counted east and west from this meridian through 180 degrees. Thus the Greenwich Meridian is the zero degree longitude on one side of the earth, and after crossing the poles, it becomes the 180th meridian (180 degrees east or west of the 0-degree meridian). Therefore we have all longitudes designated either west or east (e.g., E 140 degrees or W 90 degrees). The E and W designations define the eastern and western hemispheres.

Each degree of latitude or longitude is divided into 60 minutes, and then either 60 seconds, or tenths and hundredths of minutes to more precisely locate a position on a circle.

This system is used to precisely locate any point on the earth's surface. When identifying a location by its position within this latitude-longitude matrix, you identify the position's *coordinates,* always indicating latitude first, then longitude. For example, the coordinates N 39° 04.1' W 95° 37.3' are read as “thirty-nine degrees, four point one minutes north latitude, ninety-five degrees, thirty-seven point three minutes west longitude.” If you locate these coordinates on *any* appropriate aeronautical chart of North America, you will *always* find Philip Billard Municipal Airport in Topeka, Kansas.

It is important to remember that in the northern hemisphere, latitude numbers increase as you proceed from south to north, and decrease as you move north to south. In the western hemisphere, longitude numbers increase when proceeding east to west, and decrease when moving west to east.

7.3 Magnetic variation

Variation is the angle between true north and magnetic north. It is expressed as east variation or west variation depending upon whether magnetic north (MN) is to the east or west of true north (TN), respectively. The north magnetic pole is located close to latitude 71 degrees N., longitude 96 degrees W. -- about 1,300 miles from the geographic or true north pole. If the earth were uniformly magnetized, the compass needle would point toward the magnetic pole, in which case the variation between true north and magnetic north could be measured at any intersection of the meridians.

Actually, the earth is not uniformly magnetized. In the United States the needle usually points in the general direction of the magnetic pole but it may vary in certain geographical localities by many degrees. Consequently, the exact amount of variation at thousands of selected locations in the United States has been carefully determined by the National Ocean Survey. The amount and the direction of variation, which change slightly from time to time, are shown on most aeronautical charts as broken red lines, called isogonic lines, which connect points of equal magnetic variation. The line connecting points at which there is no variation between true north and magnetic north is the agonic line.

7.4 Airspace

By analyzing air traffic volume at specific locations, the FAA determines the levels of control required to ensure safe, smooth operations at those locations. At or near some airports, the FAA has determined that the number of daily operations is so small that no central control is required. Near larger, busier airports centralized control by a control tower may be required not only for the aircraft departing and arriving the active runways, but for all the aircraft moving on the airport surface. At an airport with an operating control tower, the pilot must talk to clearance delivery or ground control and obtain a “taxi clearance” before moving the aircraft from its parking location. Similarly, a take off clearance must be received from the tower prior to moving onto and using the active runway.

If the pilot has filed a flight plan for flight under IFR he must receive clearance to conduct the flight from the FAA. The clearance includes the approved route of flight, altitude, and initial communications procedures.

For traffic management purposes, the FAA has designated that all airspace within the United States falls into one of six different class designations. Flight within each class requires certain communication, equipment, pilot experience, and, under some circumstances, weather requirements. Specific requirements for each class are complex, but they can be simplified somewhat with several broad generalizations.

Regardless of flight rules, the most stringent requirements normally are associated with flight in airspace immediately surrounding a major airport, due to the high density of operations conducted there. Observers should be alert for required communication when it appears a search will be conducted within 40 miles of a major airport or within 5 miles of any airport having an operating control tower. These are color-coded blue on sectional charts. Major airports in this context are generally near major metropolitan areas and appear at or near the center of concentric blue-, magenta-, or gray-colored circles.

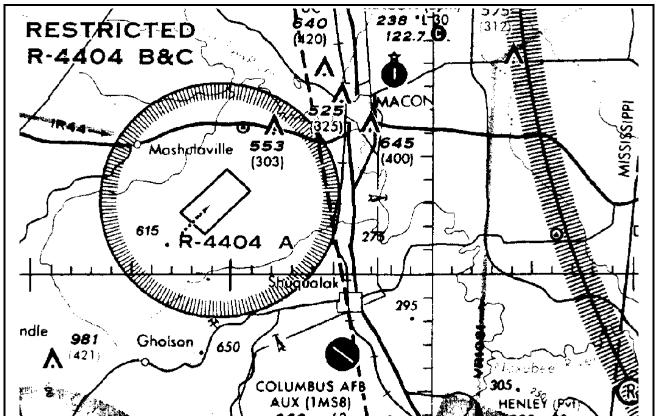


Figure 7-4

When operating the aircraft under VFR, in most classes of airspace the pilot can change the direction of flight or aircraft altitude without any prior coordination with air traffic control. This will almost always be the case when weather allows visual search patterns below the bases of the clouds. Regardless of the airspace classification, when the aircraft is operated under IFR, the pilot must receive a clearance from air traffic control prior to making any changes in direction, altitude, or route of flight.

7.4.1 Special Use Airspace

The FAA has designated some airspace as "special use" airspace. The FAA has specifically created special use airspace for use by the military, although the FAA retains control. Active special use airspace can become a navigational obstacle to search aircraft and uncontrolled objects within the airspace can present a serious threat to the safety of CAP aircraft and personnel. Special use airspace normally appears on sectional charts as irregularly shaped areas outlined by either blue or magenta hatched lines. It is also identified by either a name, such as Tyndall E MOA, or an alpha-numerical identifier like R-4404A.

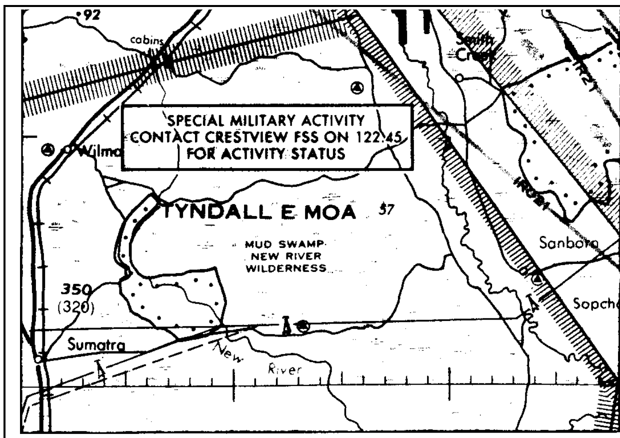


Figure 7-3

In the first example, the letters *MOA* indicate that the Tyndall E airspace is a *military operating area (MOA).* Within its boundaries the military may be conducting high-speed jet combat training or practicing air-to-ground weapons attack, without objects actually being released from the aircraft. Figure 7-3 illustrates how the MOA is portrayed on the sectional chart. MOA boundaries and their names are always printed in magenta on the sectional chart.

Civilian aircraft operating under VFR are *not* prohibited from entering an active MOA, and may do so at any time without any coordination whatsoever, although this practice is considered foolish by many pilots. As stated earlier, since the FAA retains control of the airspace, it is prudent to contact the controlling air traffic facility before continuing a search into any MOA.

Military aircraft at very low altitudes may not be in radar or radio contact with the air traffic controller, and he will not normally allow other IFR air traffic through an active MOA. The controller instead provides positive separation to civilian IFR aircraft from the MOA boundary, *not* from the military aircraft itself. This may force significant maneuvering off your intended course.

In the second example, the "R" prefix to the five-letter identifier indicates this is a *restricted* area. The Army may be conducting artillery firing within this airspace, or military aircraft may be practicing actual air-to-surface bombing, gunnery, or munitions testing. Shells, bombs, and bullets, as well as the dirt and fragments they throw into the air on impact, present a severe hazard to any aircraft that might come in their path. When a restricted area is active, that is, when the military is using the airspace, no other aircraft are allowed into that area under any conditions. Figure 7-4 illustrates how a typical restricted area is portrayed on the sectional chart. The restricted area's boundaries are always printed in blue.

Hours of use and vertical limits of special use airspace areas, as well as the FAA facility controlling each area, are printed in one of the margins of the sectional chart. If the CAP crew has any doubt about entering special use airspace, it should contact the appropriate air traffic control facility first to check the status of the area in question. The crew should *never* enter a restricted area unless *certain* military activity is not in progress.

7.4.2 Military Training Routes

Although not classified by the FAA as special use airspace, military training routes can have a similar adverse effect on a CAP team's ability to accomplish the briefed mission. An understanding of each type of training route, and the manner in which an active route can affect other traffic, will help the CAP team keep adverse effects to a minimum.

Military training routes that may be used by high-speed jet aircraft are identified by one of two designations depending upon the flight rules under which the military operates when working within that airspace. *Instrument routes* (IR) and v*isual routes (VR)* are identified on sectional aeronautical charts by medium-weight solid gray lines with an alpha-numeric designation. In Figure 7-5 there are two such examples east of the Clarksville Airport symbol -- IR-120, and VR-1102.

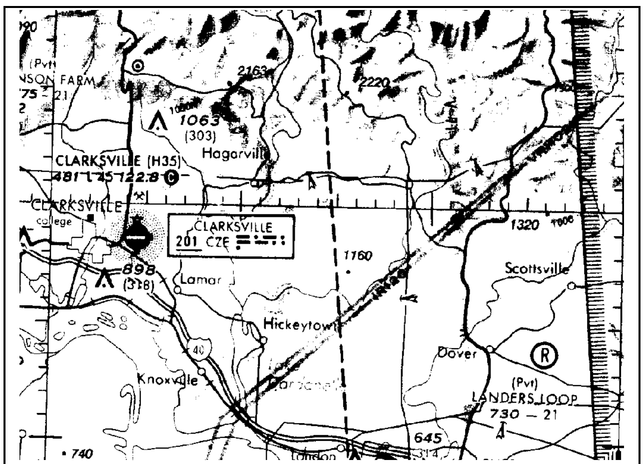


Figure 7-5

Only route centerlines are printed on sectional charts, but each route includes a specified lateral distance to either side of the printed centerline and a specific altitude "block." Route widths vary, but can be determined for any individual route by requesting Department of Defense *Flight Information Publication AP-1B*.

The letters *IR* in IR-120 indicate that military aircraft operate in that route according to IFR clearances issued by air traffic control. Other non-military VFR aircraft may enter the lateral or vertical boundaries of an active IR route without prior coordination, while aircraft operating IFR are kept out by air traffic control. Just as in the case of a MOA, air traffic control may not have radar and radio contact with the military aircraft using the route. Therefore, it is necessary to provide separation between other IFR aircraft and the route airspace regardless of where the military aircraft may be located along the route. This may force either a route or altitude change. Civil Air Patrol members can request the status of IR routes from the controlling air traffic facility.

The letters *VR* in VR-1102 indicate that the military operates under VFR when operating within the lateral and vertical limits of that airspace. The see-and-avoid concept applies to *all* civilian and military aircraft operating there, and all crew members must be vigilant in visual lookout when within or near a VR training route. Many military missions go to and from visual training routes' start and exit points on IFR clearances, and the prudent crew can inquire about the status of the route with air traffic control when operating through or near a VR training route.

You can determine *scheduled* military activity for restricted areas, MOAs, and on military training routes by checking *Notices to Airmen*. However, checking with the air traffic control facilities is preferable, since it will reveal *actual,* "real time" activity versus *scheduled* activity. When flying through any special use airspace or training route, crewmembers should be cautious at all times. Never assume that ATC will warn you of approaching traffic, and never assume that low-flying, high-speed military aircraft will either be looking for you or be able to see you.

7.4.3 Special Coordination and Communication

The procedures the FAA has developed to help manage air traffic, from a practical viewpoint, are primarily oriented towards an operator moving an aircraft between two points. They frequently can constrain flights whose primary purpose is different. In many cases, the FAA has lesser-known procedures in place that may allow operations that seem contrary to the standard.

If fulfilling a special requirement does not involve deviating from FAA regulations, in many cases a personal telephone call by the incident commander to the facility in question, with an explanation of the requirement, can lead to FAA concurrence on a temporary procedure. Crewmembers, especially pilots, must be careful that temporary procedures do not violate FAA regulations. An air traffic controller or supervisor has the authority to authorize deviations from FAA regulations in only a very few circumstances.

7.5 Electronic Aids to Navigation (Navaids)

The most important part of using any navigation method is starting from a known position or *fix.* Obviously, if you don't know precisely where you are to start with, you can't very well know the right direction and distance to travel in order to reach the next landmark. Likewise, if you fly a 050° heading for 16 minutes, but you don't know where you started from, the dead reckoning will most likely be futile. This section will cover some of the electronic means available that can help in navigating. These systems help you determine your position in reduced visibility or over featureless terrain and, more importantly, help you fly precise search patterns and accurately report your observations to ground teams or the mission base.

Most airplanes flown in today's environment have equipment that provide a means of navigation and communication with ground stations (nav-comms). Advances in navigational radio receivers (particularly GPS) in airplanes, the development of aeronautical charts which show the exact location of ground transmitting stations and their frequencies, along with refined cockpit instrumentation make it possible for aircrews to navigate with precision to almost any point desired.

7.5.1 Automatic direction finder (ADF)

The automatic radio compass, generally known as the Automatic Direction Finder (ADF), is used to receive radio guidance from stations such as four-course ranges, radio beacons, and commercial broadcast facilities. The automatic direction finder indicates the direction of the station being received. This direction is shown in relation to the heading of the aircraft. Operation of the automatic direction finder is based on the direction-finding characteristics of the loop antenna. When the plane of the loop is located at right angles to an imaginary line extending to the transmitting station, the signals received are very weak. With the plane of the loop antenna perpendicular to the longitudinal axis of the aircraft, only weak signals are received when the aircraft is headed either toward or away from a tuned station. The ADF indicating needle then points to zero, showing that the aircraft is on course to the tuned station.

Probably the most common use of the automatic direction finder is in “homing”. The pilot tunes in a desired station, then flies directly to that station by keeping the ADF indicating needle on the zero mark. When the needle points to the zero mark, the aircraft is headed toward the station. When the station is passed, the needle will swing around to the 180 degree position, indicating that the station is behind. The pilot may also tune to two or more stations and plot the bearings received on an aeronautical chart to fix his position. He may also tune to a single station, obtain a bearing, and combine this line of position with a radio range signal to fix his position. Although ADF does not compensate for wind drift and is vulnerable to static, it is a valuable radio navigation aid in cross-country flying.

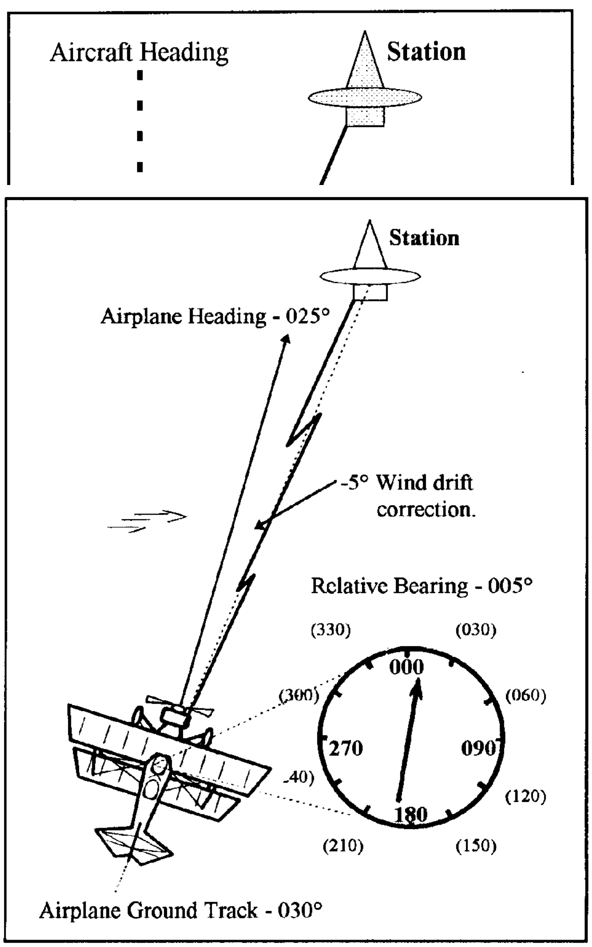


Figure 7-8

The automatic direction finder (ADF) has three primary components -- a transmitter on the ground, a receiver and an indicator, both in the aircraft. Transmitters include NDB, or non-directional radio beacons, and commercial AM radio stations. Each transmitter emits a single signal on a specific frequency in all directions. ADF equipment aboard the aircraft indicates the *relative* bearing of the station, or its relative direction from the aircraft. In Figure 7-6, the airplane is shown flying north, or flying both a heading and a course of 000°. The ADF “indicator” illustrated shows the direction to the transmitter is 30 degrees to the right of the plane's nose. In the illustration only 0, 090, 180, and 270 are shown on the indicator, and that is true of many ADF indicators. You may have to interpret index marks between these major bearings to determine the exact bearing to the station.

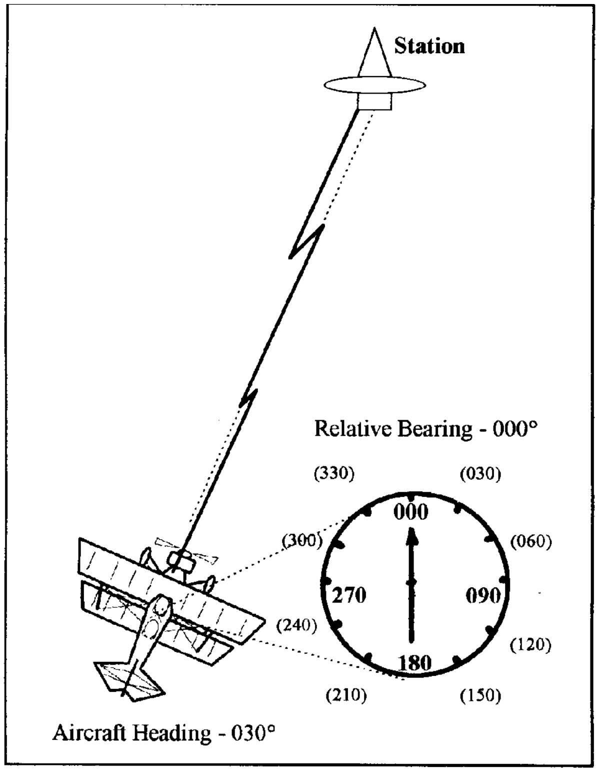


Figure 7-7

If you turn the aircraft 30 degrees to the right, to a heading of 030°, the plane will point directly at the station, and the pointer will now point at 0 relative bearing. In a no-wind condition, if you maintained that 030° heading and the pointer at 0 relative bearing, you would fly directly to that transmitter, as shown in Figure 7-7.

In a crosswind, the pilot estimates the airplane's drift, and computes a drift correction factor to be added to or subtracted from the aircraft heading. If he estimates 5 degrees of drift to the right, his drift correction will be to subtract 5 degrees from the airplane's heading, and turn the aircraft 5 degrees to the left. The aircraft would thus have a heading of 025°, its course over the ground would remain 030°, and the ADF would show a relative bearing of 005°, or 5 degrees to the right, as shown in Figure 7-8. In the rowboat-crossing-the-river analogy, the boat's bow points upstream, but due to the current it travels in a straight line across the river. The aim point is slightly to the right of the bow as the boat proceeds across.

When tracking, unless the effect of wind is taken into account, the airplane will follow a curved path. Slight amounts of wind and drift can be difficult to detect, and a *slightly* curved path may result regardless, but the crew should try to keep the curve to a minimum because it wastes both time and fuel. When the aircraft passes over the station, the pointer will swing from approximately 000 degrees to approximately 180 degrees relative bearing.

This system is only good for proceeding directly to or from the station. Returning to the northbound airplane in Figure 7-8, the stations initial relative bearing was determined to be 30 degrees right. When the compass showed a heading of 000°, it was necessary to add 30 degrees to determine a *magnetic bearing* to the station. When the magnetic bearing *to* the station is 030 degrees, the aircraft's "mag" bearing *from* the station is the reciprocal of 030°, or 210°. To determine the reciprocal, add or subtract 180°. If you then locate the station or NDB on the sectional and apply the magnetic variation to determine your true bearing from the station, you can draw a line of position on the chart.

With another line of position from a different station, you can find your location where the two lines intersect. It requires a great deal of proficiency to do this accurately using one receiver, but using a second ADF or another type of navigation radio makes the process easier.

All ADF stations transmit an audible identifier that you must identify before using the signal for navigation. All ADFs are highly susceptible to interference when thunderstorms are in the general vicinity, and their transmissions are restricted to line-of-sight only. Signals can be blocked by terrain or other obstructions, especially when the aircraft is operating at low altitudes.

The requirement for aircraft to have an ADF unit is being phased out as use of the GPS becomes more widespread.

7.5.2 Very High Frequency Omnidirectional Range (VOR)

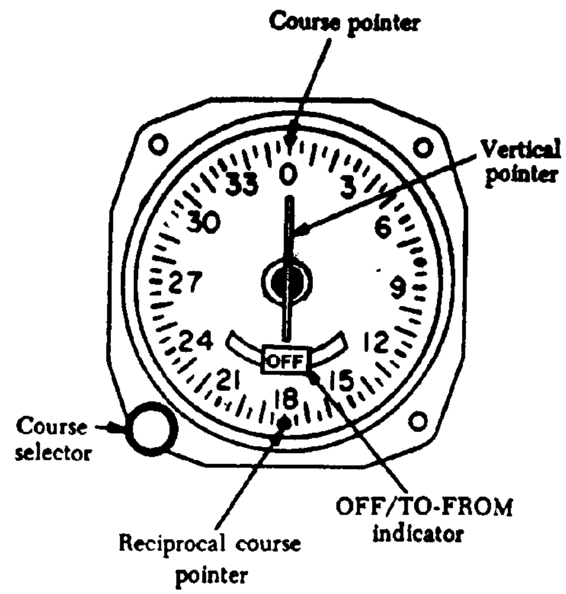


Figure 7-9

Very high frequency omnidirectional range (VOR) is a more accurate radio navigation system. Each operates on a specific frequency in the VHF range of 109.0 to 117.9 megahertz and transmits 360 directional radio beams or *radials* that, if visible, would resemble the spokes radiating from the hub of a bicycle wheel. Each station is aligned to magnetic north so that the 000 radial points from the station to magnetic north. Every other radial is identified by the magnetic direction to which it points from the station, allowing the pilot to navigate directly to or from the station by tracking along the proper radial.

Like the ADF, the main components are in three pieces: the ground transmitter, the receiver, and the indicator. Controls on the receiver include a power switch, frequency selector knobs and display window, and a volume control.

To help pilots plan and choose routings, the FAA has developed the Victor airway system, a “highway” system in the sky that uses specific courses to and from selected VORs. When tracing the route of a missing aircraft, search airplanes may initially fly the same route as the missing plane, so it is very important you know the proper procedures for tracking VOR radials.

Figure 7-9 shows a VOR indicator and the components that give the information needed to navigate, including a vertical pointer, OFF/TO-FROM flag or window, and a course-select knob. The vertical pointer, also called a course deviation indicator (CDI), is a vertically mounted needle that swings left or right to show the airplane's location in relation to the course selected beneath the course pointer. The OFF/TO-FROM indicator shows whether the course selected will take the airplane to or from the station. When it shows “OFF”, the receiver is either not turned on or it’s not receiving signals on the selected frequency. The course selector knob is used to select the desired course to fly either toward or away from the station.

Flying to the VOR station is simple. Find the station’s frequency and its Morse code audio identifier using the sectional chart. Next, tune the receiver to the correct frequency and identify the station by listening to its Morse code. If you can’t positively identify the station, you should not use it for navigation.

After identifying the station, slowly turn the course selector knob until the TO-FROM indicator shows TO and the CDI needle is centered. If you look at the course that's selected beneath the course pointer at the top of the indicator, you'll see the course that will take you directly to the station. The pilot turns the aircraft to match the airplane's heading with that course and corrects for any known winds by adding or subtracting a drift correction factor. The pilot keeps the CDI centered by using very small heading corrections and flies the aircraft directly to the station. When the aircraft passes over the station, the TO-FROM indicator will flip from TO to FROM.

To fly away from a station, tune and identify the VOR, then slowly rotate the course select knob until the CDI is centered with a FROM indication in the window. Look at the selected course, again normally at the top of the indicator, to determine the outbound course. The pilot turns the aircraft to that heading, corrects for wind drift, and keeps the CDI needle in the center to fly directly away from the station.

Figure 7-10 shows a hypothetical VOR with the 0° inbound and outbound courses simulating a Victor airway. In order to fly that airway, set 0° beneath the course pointer and determine the aircraft's position relative to the selected course. Each airplane has the 0° course selected under its course pointer, but the top airplane has a "FROM" indication. This indicates that the plane is north of the station. The vertical pointer's right deflection indicates that the desired 0° course from the station is off to the right. Since the plane is flying about a 330° heading, the pilot would turn back to the right to join the 0° course outbound from the station.

The indicator in the airplane southeast of the station has a "TO" indication, which, with the 0° course selected, indicates it's south of the station. The pointer's left deflection indicates the 0° course to the station is to the plane's left. Since this plane also is heading 330°, it does not need to turn farther to *intercept* the 0° course to the station.

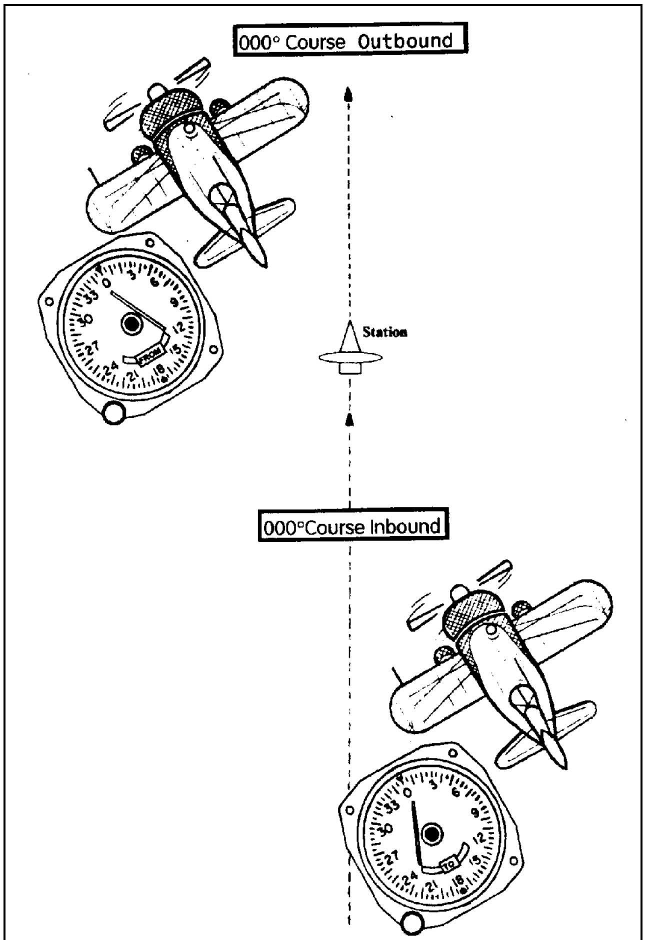


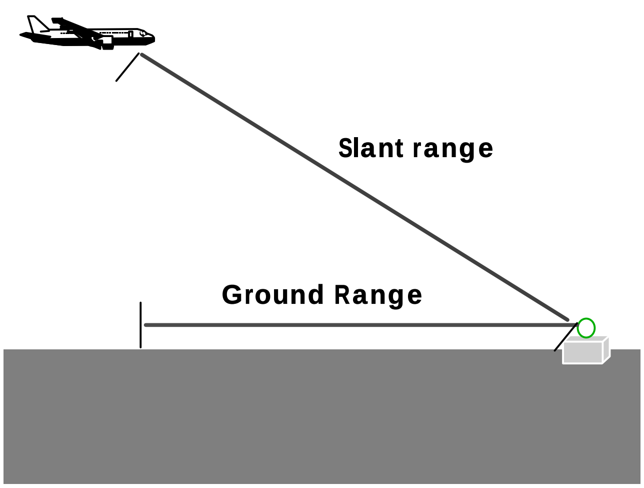
Figure 7-10

The display in the north plane would show the same indications if it were heading 360° or 030°, since in any case the 0° course from the station is still to the right. Likewise, the south plane would have the same indications regardless of the direction it's pointed. <u>At any given point in space, the VOR display always gives the same indication regardless of the direction the airplane is pointing.</u>

VOR can be used like ADF to determine a position in relation to a selected station, and the process is considerably simpler due to the directional nature of the VOR's signals. Rotate the course select knob slowly until the CDI is centered with a FROM indication, and look beneath the reciprocal course pointer for the radial. You can draw that radial as a line of position from the station's symbol on the sectional chart.

Each VOR station on the chart has a surrounding compass ring already oriented towards magnetic north. Therefore, it isn't necessary to correct for magnetic variation. The use of the printed compass circle surrounding the station on the chart eliminates the need for using the plotter's protractor as well. Use any straight edge to draw the radial by connecting the station symbol with a pencil line through the appropriate radial along the circle. The radial drawn on the chart shows direction, but does not indicate distance from the station. But, you can get an accurate position "fix" by repeating the procedure with another VOR.

Using VOR has several advantages over using ADF. The directional nature of the VOR transmissions makes them easier to use for navigation than the non-directional signal from a NDB. Signals from VORs are also much less susceptible to interference from thunderstorms and static electricity produced by weather phenomena. The directional signals from VOR's also make it much easier to correct for crosswinds. Like ADF, VOR is limited by signal blockage from high terrain and obstructions, or during flight at very low altitudes.



7.5.3 Distance Measuring Equipment (DME)

Finding bearing or direction to a station solves only one piece of the navigation puzzle. Knowing the distance to the station is the final piece to the puzzle that allows fliers to navigate more precisely. You can use crossing position lines from two radio stations to obtain your distance from the stations, but an easier method is provided by distance measuring equipment (DME).

DME continuously measures the distance of the aircraft from a DME ground unit that is usually co-located with the VOR transmitter (called a VORTAC). The system consists of a ground-based receiver/transmitter combination called a transponder, and an airborne component called an interrogator. The interrogator emits a pulse or signal, which is received by the ground-based transponder. The transponder then transmits a reply signal to the interrogator. The aircraft's DME equipment measures the elapsed time between the transmission of the interrogator's signal and the reception of the transponder's reply and converts that time measurement into a distance.

This measurement is the actual, straight-line distance from the ground unit to the aircraft, and is called *slant range*. This distance is continuously displayed, typically in miles and tenths of miles, on a dial or digital indicator on the instrument panel. When DME is used in combination with VOR, a pilot can tell at a glance the direction and distance to a tuned station.

Since DME measures straight-line distance, or slant range, there is always an altitude component within the displayed distance. If you fly toward a station at an altitude of 6,000 feet over the station elevation, the DME will never read zero. It will continuously decrease until it stops at one mile. That mile represents the aircraft's altitude above the station. The distance readout will then begin to increase on the other side of the station. Under most circumstances the altitude component of slant range can be ignored, but when reporting position using DME, especially to air traffic controllers, it is customary to report distances in "DME", not nautical miles, e.g., "Holly Springs 099° radial at 76 DME."

Some DME equipment can also compute and display the actual ground speed of the aircraft, provided that the aircraft is flying directly to or from the ground station. In all other circumstances, the ground speed information is not accurate and should be ignored.

7.5.4 LORAN

Long Range Navigation (LORAN) is a navigational system that utilizes low frequency radio stations to determine the aircraft position with, under most conditions, considerably greater accuracy than ADF, VOR, or DME. It operates in the 90 to 110 kHz frequency band and is based upon measurement of the difference in time of arrival of radio frequency energy pulses. These pulses are radiated by a chain of transmitters that are separated by hundreds of miles. Within a chain, one station is designated as the master station (M), and the other stations are designated as secondary stations as shown in Figure 7-11. Signals transmitted from the secondary stations are synchronized with those from the master station. The measurement of a time difference (TD) is made by a receiver that compares a zero crossing of a specified radio-frequency cycle within the pulses received from the master and secondary stations of a chain. Loran provides predictable accuracy of 0.25 nautical miles or better, depending on the user's location within the signal coverage area in certain coastal regions of the chain.

The basic operating principle is that radio waves travel through the atmosphere at near constant speed. You may recall from the dead reckoning lesson that speed and time can be used to determine the distance traveled from a known start point. Similarly, a LORAN radio precisely measures the amount of time required to receive a radio signal from the instant it's transmitted, and uses the known speed of the radio waves to determine the distance from that transmitter.

A LORAN system consists normally of no fewer than three ground-based transmitters and three airborne components -- a receiver, time measuring device, and a digital computer processor. The receiver, time measuring device, and processor are normally enclosed within the same case by the manufacturer, with a control panel and indicators on the front of the case. Transmitters are collectively known as a *chain*, and

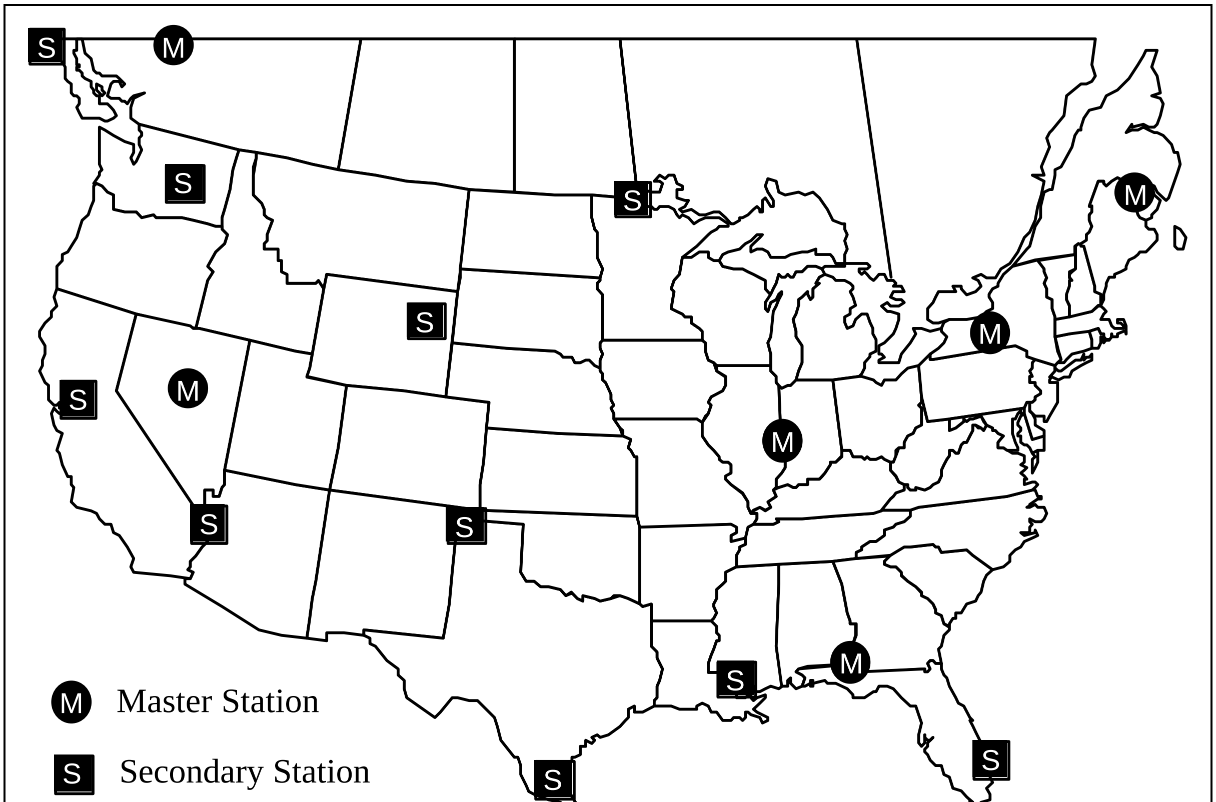


Figure 7-11

operate within the chain as either the master primary transmitter or as one of the slave secondary transmitters. Each chain must have one master transmitter and at least two slave transmitters.

A LORAN master station transmits a signal, which is echoed by each slave station at a precise, predetermined time interval. The airborne receiver component receives the signal first from the master transmitter, followed by the signals from each slave station. The time measuring device determines the time differences between reception of the master signal and each slave signal. The processor converts these time measurements into distances, and then computes the receiver position by mathematically triangulating the calculated distances from the known positions of the stations. For clarity from this point on, all the airborne components will be referred to collectively as the receiver.

Although the individual features of LORAN receivers may vary according to the manufacturers' designs, almost all have digital readouts where the pilot or observer can directly read the latitude and longitude coordinates of the receiver's/aircraft's present position. Most systems have additional navigational features that can be very useful on search and rescue missions. LORAN features may include programmable waypoints, course deviation and ground speed readouts, and a capability to "freeze" or "mark" the present position display only, while the receiver and processor continue to calculate updates.

The utility of these systems on a visual search is limited only by the system's individual features and the imagination of the crew using the system. For instance the aircrew can program two or more navigational points into the system and use it to fly the base segment for either a parallel track or creeping line search pattern with significantly increased accuracy. Then using the course deviation or track error features, the crew can more precisely fly every successive leg at the track spacing directed by the incident commander. Then after locating a possible lead or the crash site itself, they can use the "freeze" or "mark" function when directly overhead the site and accurately obtain coordinates of the location.

LORAN systems, while having great utility, are vulnerable to certain system problems that can degrade their performance. Because the transmitters are ground-based, high terrain or obstructions between the transmitters and the receiver can block the signal. Ground interference can similarly affect signal reception at very low altitudes even over flat terrain, depending upon the receiver's distance from the chain stations. Signals are also vulnerable to interference from severe electrical storms. Frequently, when the receiver momentarily loses one or more of the stations, the displayed position stays at the last position prior to the signal loss. When the lost signal is acquired again, the calculations resume and the correct position will return. In the interim, however, the "stuck" position is not updating and can give the crew an erroneous indication. Crewmembers are also cautioned to check the instructions of the individual LORAN for the stored chain data. Ground station frequencies and time-delay intervals used within the chains in many cases cannot be “tuned” by the crew, having been permanently programmed by the manufacturer instead.

The FAA has not approved all LORAN receivers for use in instrument flight conditions, and CAP does not have any IFR-certified LORAN units. A small placard or label on the aircraft instrument panel will list the conditions for use. Unless you are *certain* the receiver and its installation are approved for operations in instrument conditions, LORAN should only be used in visual weather conditions.

LORAN should complement navigational techniques previously discussed and should not be used as a sole substitute for good pilotage and dead reckoning. To a new operator, many LORANs are not "user friendly" and can significantly <u>increase</u> the user's workload. Crewmembers anticipating LORAN use should read the operating manual or instructions and become thoroughly familiar with LORAN operation before flight, so that operating the LORAN will not become a distraction from more important tasks.

LORAN units are being replaced by GPS in all CAP aircraft.

7.5.5 Global Positioning System (GPS)

Initially developed by the Department of Defense for military users, the Global Positioning System is a navigational system that is quickly becoming the standard navigational system for aircraft. The GPS represents a tremendous improvement in search and rescue/disaster assessment capabilities by enabling us to fly precisely without reference to ground features. This increases search effectiveness in terms of search coverage, fuel efficiency, and safety. For this reason, all pilots and observers must become thoroughly familiar with their GPS unit's capabilities and integrate the GPS into their missions.

The system relies on a chain of 24 satellite transmitters in polar orbits about the earth. The speed and direction of each satellite, as well as each satellite's altitude, is precisely maintained so that each satellite remains in a highly accurate and predictable path over the earth's surface at all times.

GPS receivers process signals transmitted by these satellites and triangulate the receiver's position, which the user again can read directly in latitude and longitude coordinates from a digital display. Similar additional features as those discussed in LORAN are available and vary depending upon the design and manufacturer. The system is substantially more accurate than LORAN, VOR, DME, or ADF and has several advantages.

Because the transmitters are satellite based, not ground based, and the signals are essentially transmitted *downward,* system accuracy is not significantly degraded in mountainous terrain. Additionally, the system is not normally vulnerable to interference from weather or electrical storms. Receivers can typically process more than eight received signals simultaneously, and can automatically deselect any satellite whose signal doesn't meet specific reception parameters. The system can function with reasonable accuracy using as few as three received signals.

As certain limitations are overcome, IFR-certified GPS units will replace the ADF and VOR systems. CAP aircraft, however, are equipped with VFR-only GPS units, so they will have to maintain the ADF and VOR units in order to be instrument-certified aircraft. Operations using GPS should be conducted only in VFR flight conditions, and should be complemented by other navigational techniques. GPS should not be used as the sole navigational instrument.

7.6 Sectional Charts

The most important tool you will use in both mission planning and execution is the chart. Although the earth is spherical, not flat, cartographers can portray small portions of the earth's surface as though it *is* a flat surface, without affecting accurate navigation. Visual air navigation charts must have certain basic features including:

- Navigational reference system superimposed over the terrain depiction.
- Identifiable, measurable scale to measure distances.
- Detailed graphic depiction of terrain and culture, or man-made features.

Highway road maps are usually not acceptable for air navigation, since most don't have detailed terrain depiction and also lack the superimposed reference system. Many aeronautical charts have such small scales that the makers are unable to show required levels of detail when trying to put a large area into a small chart space. The most useful chart that has been widely accepted for visual, low-altitude navigation is the *sectional aeronautical chart,* sometimes simply referred to as the *"sectional".*

Sectionals use a scale of one to five hundred thousand, or 1:500,000, where all features are shown 1/500,000 of their actual size. This allows accurate depiction of both natural and cultural features without significant clutter.

Sectionals portray the following:

- physical, natural features of the land, including terrain contours, or lines of equal elevation.
- man-made or cultural development, like cities, towns, towers, and race tracks.
- navigational radio stations, airways, and military-use airspace.
- radio frequencies, airport data, lines of magnetic variation, and other important information.

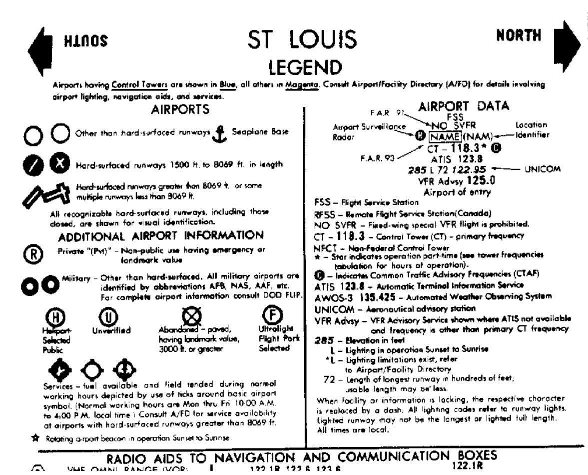


Figure 7-12

The most important part of the sectional or any other chart is the legend. This is a written explanation of symbols, projections, and other features used on the chart. Figure 7-12 illustrates a portion of the St. Louis sectional chart legend. Other important areas of the sectional chart are its title page or "panel", and the margins around the chart edges. The margins contain supplemental radio frequency information, details about military or *special use airspace,* and other applicable regulations. The title panel identifies the region of the country shown by the chart, indicates the scale used in drawing the chart, explains elevations and contour shading, and shows the expiration date of the chart and effective date of the next issue of that chart. Expired charts should not be used on missions because information on the charts may no longer be correct.

The National Ocean Survey (NOS) publishes and sells aeronautical charts of the United States and of foreign areas. The type of charts most commonly used by VFR pilots are:

- Sectional Charts. The scale of the Sectional Chart is 1:500,000 (1 inch = 6.86 NM)
- VFR Terminal Area Charts. The scale of a VFR Terminal Area Chart is 1:250,000 (1 inch = 3.43 NM).

These charts are designed for visual navigation of slow/medium speed aircraft. The topographical information featured on these charts consists of the portrayal of relief and a judicious selection of visual checkpoints used for VFR flight. The checkpoints include populated places, drainage, roads, railroads and other distinctive landmarks.

The aeronautical information on sectional charts includes visual and radio aids to navigation, airports, controlled airspace, restricted areas, obstructions and related data.

VFR Terminal Area Charts depict Class B airspace on a scale of 1:250,000. One side of the chart shows information similar to that found on a sectional chart, but in greater detail. The other side is a charted VFR flyway planning chart, which identifies VFR flyways designed to help VFR pilots avoid major controlled traffic flows; these may be used as alternates to flight within the established Class B airspace. Its ground references provide a guide for improved visual navigation. The chart is for information and planning purposes only.

Both the Sectional and VFR Terminal Area Charts are revised semi-annually. Information on the charts change more frequently than this, and consolidated updates are available every 56 days in the Airport/Facility Directory (A/FD). Aircrews can also consult appropriate Notices to Airmen (NOTAMs) and other Flight Information Publications (FLIPs) for the latest changes.

It is vitally important that pilots check the publication date on each aeronautical chart to be used. Obsolete charts should be discarded and replaced by new editions. This is important because revisions in aeronautical information occur constantly. These revisions include changes in radio frequencies, new obstructions, temporary or permanent closing of certain runways and airports, and other temporary or permanent hazards to flight. To make certain that the sectional aeronautical chart being used is up-to-date, refer to the National Ocean Survey (NOS) Aeronautical Chart Bulletin in the Airport/Facility Directory (A/FD). This bulletin provides the VFR pilot with the essential information necessary to update and maintain current charts. It lists the major changes in aeronautical information that have occurred since the last publication date of each chart:

- changes to controlled airspace.
- changes special use airspace that present hazardous conditions or impose restrictions on the pilot.
- major changes to airports and to radio navigational facilities.

7.7 Chart Interpretation

A significant part of air navigation involves interpreting what one sees on the chart, then making comparisons outside the aircraft. It is most important that observers be thoroughly acquainted with the chart symbology explained in the chart legend, and the relief information discussed on the chart's title panel.

Basic chart symbology can be grouped into cultural features, drainage features, and relief features. Understanding cultural features is straightforward, and they usually require little explanation. Villages, towns, cities, railroads, highways, airports or landing strips, power transmission lines, towers, mines, and wells are all examples of cultural features. The chart legend explains the symbology used for most cultural features, but if no standard symbol exists for a feature of navigational significance, the cartographer frequently resorts to printing the name of the feature itself, such as *factory* or *prison,* on the chart.

Drainage features on charts include lakes, streams, canals, swamps, playas, and other bodies of water. On sectionals these features are represented by light-weight solid blue lines for rivers and streams. Large areas of water, such as lakes and reservoirs, are shaded light blue with the edges defined by light-weight solid blue lines. Under most conditions, the drainage features on a map closely resemble the actual bodies of water. However, certain bodies of water may change shape with the season, or after heavy rains or drought. Where this shape change occurs with predictability, cartographers frequently illustrate the maximum size expected for a body of water with light-weight blue, dashed lines. If you intend to use drainage features for navigation, you should consider recent rains or dry spells while planning and remember the body of water may not appear exactly as depicted on the chart.

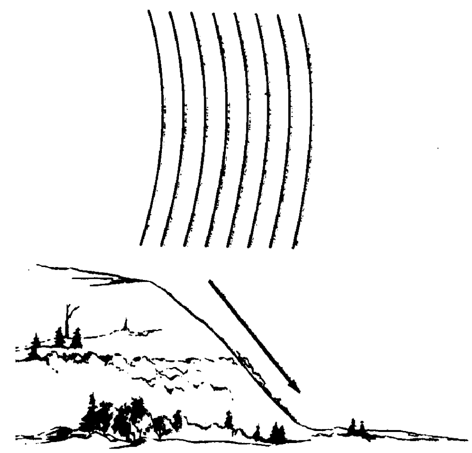


Figure 7-13

7.7.1 Relief

Relief features indicate vertical topography of the land including mountains, valleys, hills, plains, and plateaus. Common methods of depicting relief features are contour lines, shading, color gradient tints, and spot elevations. Contour lines are the most common method of depicting vertical relief on charts. Although the lines do not represent topographical features themselves, through careful study and interpretation you can predict a feature's physical appearance. Each contour line represents a continuous imaginary line on the ground on which all points have the same elevation above or below sea level, or the zero contour. Actual elevations above sea level of many contour lines are designated by a small break in the line, while others are not labeled. Contour interval, or the vertical height between each line, is indicated on the title panel of sectionals.

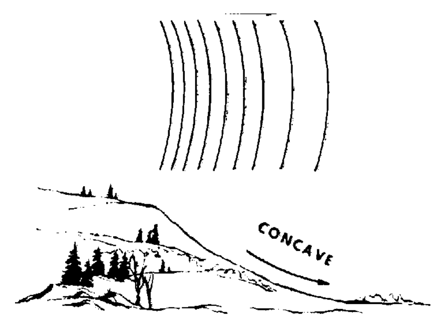


Figure 7-14

Contour lines are most useful in helping us to visualize the vertical development of land features. Contour lines that are grouped very closely together, as in Figure 7-13, indicate rapidly changing terrain, such as a cliff or mountain; more widely spaced lines indicate more gentle slopes. The absence of lines indicates flat terrain.

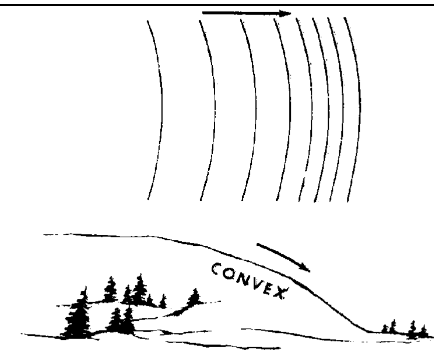


Figure 7-15

Contour lines can also show changes in the slope of terrain. Figures 7-14 and 7-15 show how to predict the appearances of two hillsides based upon their depictions on a chart.

Precise portrayal and interpretation of contour lines allows accurate prediction of the appearance of the terrain you expect to fly over or near. Figure 7-16a shows the depiction of a saddle in a short ridgeline, and Figure 7-16b shows how it might appear from the aircraft. Many other types of terrain features can be predicted by careful study

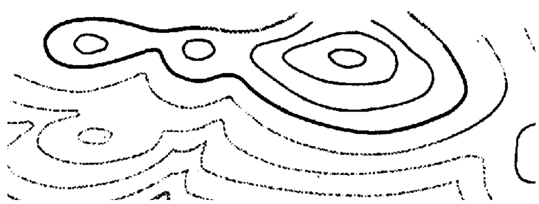


Figure 7-16a


Figure 7-16b

of contour lines. An outdated chart can be a useful tool for helping to develop your skills, but don't use it for navigation in flight.

Shading is added to sectional charts to help highlight and give contrast to the contour lines. These tiny gray dots are applied adjacent to selected contour lines and give the contours a three-dimensional appearance. This makes it easier to imagine the physical appearance of the shaded topographical feature.

Gradient tints, the "background" colors on charts, indicate general areas of elevation. The height range assigned to each gradient color is indicated on the title panel of each sectional chart. Areas that are near sea level are pale green, while high terrain is color-coded a deep red/brown. Intermediate elevations are indicated by brighter shades of green, tan, or lighter shades of red/brown.

A spot elevation is the height of a specific charted point. On sectional charts, this height is indicated by a number next to a black dot, the number indicating the height of the terrain above sea level.

7.7.2 Aeronautical Data

The aeronautical information on the sectional charts is for the most part self-explanatory. Information concerning very high frequency (VHF) radio facilities such as tower frequencies, omnidirectional radio ranges (VOR), and other VHF communications frequencies is shown in blue. A narrow band of blue tint is also used to indicate the centerlines of Victor Airways (VOR civil airways between omnirange stations). Low frequency-medium frequency (LF/MF) radio facilities are shown in magenta (purplish shade of red).

In most instances FAA navigational aids can be identified by callsigns broadcast in International Morse Code. VOR stations and Non-directional Radio Beacons (NDB) use three-letter identifiers which are printed on the chart near the symbol representing the radio facility.

Runway patterns are shown for all airports having permanent hard-surfaced runways. These patterns provide for positive identification as landmarks. All recognizable runways, including those that may be closed, are shown to aid in visual identification. Airports and information pertaining to airports having an airport traffic area (operating control tower) are shown in blue. All other airports and information pertaining to these airports are shown in magenta adjacent to the airport symbol which is also in magenta.

The symbol for obstructions is another important feature. The elevation of the top of obstructions above sea level is given in blue figures (without parentheses) adjacent to the obstruction symbol. Immediately below this set of figures is another set of lighter blue figures, enclosed in parentheses, which represents the height of the top of the obstruction above ground level. Obstructions which extend less than 1,000 feet above the terrain are shown by one type of symbol and those obstructions that extend 1,000 feet or higher above ground level are indicated by a different symbol (see sectional chart). Specific elevations of certain high points in terrain are shown on charts by dots accompanied by small black figures indicating the number of feet above sea level.

The chart also contains larger bold face blue numbers which denote Maximum Elevation Figures (MEF). These figures are shown in quadrangles bounded by ticked lines of latitude and longitude, and are represented in THOUSANDS and HUNDREDS of feet above mean sea level. The MEF is based on information available concerning the highest known feature in each quadrangle, including terrain and obstructions (e.g., hills, towers and antennas).

An explanation for most symbols used on aeronautical charts appears in the margin of the chart. Additional information appears at the bottom of the chart.

7.8 Chart Preparation

Careful chart preparation and route study before the flight can increase your efficiency and decrease your workload during the flight. You should try to develop a systematic approach to chart preparation. Thorough preparation is necessary, even with the advent of Global Positioning System (GPS) technology.

The first step in planning any leg is to locate the departure point and destination on the chart, and lay the edge of a special protractor, or plotter, along a line connecting the two points, as shown in Figure 7-17. Read the true course for this leg by sliding the plotter left or right until the center point, or grommet, sits on top of a line of longitude. When the course is more to the north or south, you can measure it by centering the grommet on a parallel of latitude, then reading the course from the inner scale that's closer to the grommet.

The discussion that follows concerns one leg of a flight from University-Oxford airport, near Oxford, Mississippi, to the Ripley airport, near Ripley, Mississippi. The same basic principles used in planning this single leg are used in all air navigation and apply to more complex search patterns.

In Figure 7-18, the chart for this "flight," two points are connected with a solid line. This line represents the *true* course from Oxford to Ripley and is 051°. If you were interested in going the opposite direction, the course would be the *reciprocal* course, 231°, which also appears on the arc of the plotter. Remain aware of the relationship among general directions -- north, east, south, and west -- and their directions indicated by degrees on the compass -- 000°, 090°, 180°, and 270°, respectively. Since almost all charts are printed with north to the top of the chart, you can look at the intended direction of flight, which runs right and up, or to the northeast, and know immediately that 051° is correct and 231° is not.

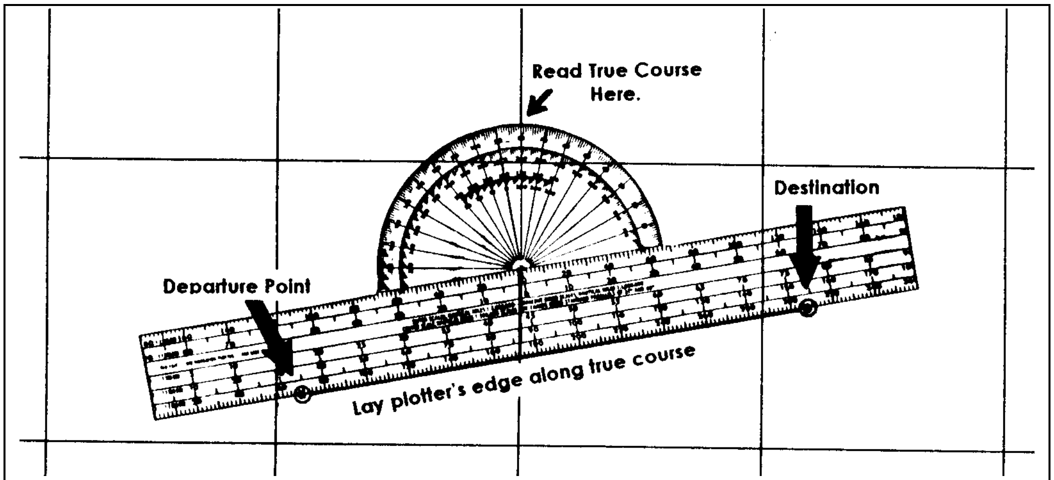
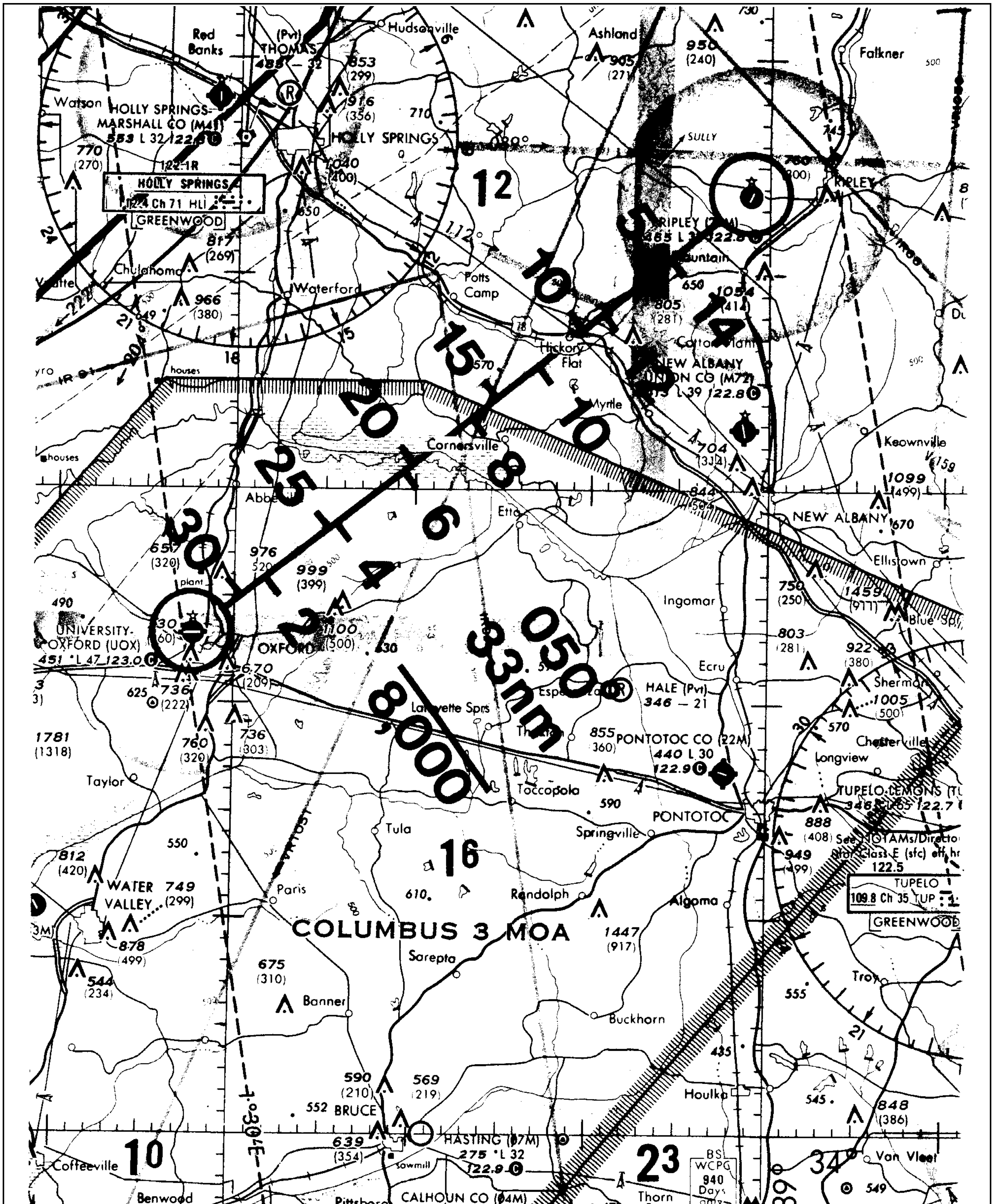


Figure 7-17

Notice the broken line that nearly passes through the Oxford airport symbol, and follow it toward the bottom of the page. Near the bottom, you'll see the numbers 1°30' E. This is the magnetic variation correction factor for that area.

If you subtract east variation or add west variation to the true course, you can determine the magnetic course. Most fliers advocate writing the "mag" course right on the chart. Round 1° 30' down to 1° and subtract that from the true course to obtain 050° for the magnetic course. Also notice that Oxford is within the boundaries of the Columbus 3 Military Operating Area (MOA). To avoid an unpleasant encounter with a high-speed jet, you can look at the table in the chart's margin, partially shown in Figure 7-19, and determine that jets using this area do not operate below 8,000 feet. You can note this on the chart with a line over 8,000, which means to remain below 8,000 feet.



Red Banks
(Pvt) THOMAS
Hudsonville
Ashland
Falkner
Watson
HOLLY SPRINGS-MARSHALL CO (M41)
583 L 32 122.8
HOLLY SPRINGS
HOLLY SPRINGS
112.4 Ch 71 HLI
GREENWOOD
RIPLEY
RIPLEY (24M)
12
Chulahoma
Waterford
Potts Camp
Hickory Flat
NEW ALBANY UNION CO (M72)
L 39 122.8
Myrtle
Cornersville
Keownville
NEW ALBANY
Ellistown
Etta
Ingomar
UNIVERSITY-OXFORD (UOX)
451 L 47 123.0
OXFORD
Ecru
HALE (Pvt)
346 — 21
Lafayette Sprs
Esperanza
PONTOTOC CO (22M)
440 L 30
122.9
Sherman
Chesterville
Longview
TUPELO LEMONS
Taylor
Toccopola
PONTOTOC
Springville
Tula
16
See NOTAMs/Directory
122.5
TUPELO
109.8 Ch 35 TUP
GREENWOOD
WATER VALLEY
Paris
Randolph
Algoma
COLUMBUS 3 MOA
Sarepta
Banner
Troy
Buckhorn
Houlka
BRUCE
HASTING (07M)
275 L 32
122.9
Coffeeville
10
23
Benwood
Pittsboro
CALHOUN CO (04M)
Thorn
Van Vleet
050
33nm
8,000

Figure 7-18

Next you must determine the total distance you’re going to fly. Measure this using the scale that's printed on the plotter's straight edge, making sure you use a scale appropriate to the scale of the chart. Use the 1:500,000 scale for sectionals. As an alternative, lay a paper's edge along the course line, make pencil marks on the paper's edge at the two airports, and then lay that same edge along the line of latitude. By simply counting the minute marks on the chart's latitude line that fall between those two pencil marks, you can determine the distance between the two airports in nautical miles. In the example, Oxford and Ripley are 33 nm, or 33 nautical miles, apart.

There are a number of ways you can add information to your chart that will help during the flight. Each flier has his own techniques or variations of the techniques presented here, and over time, you will develop a preference for methods that work best for you.

Tick marks along the course line at specific intervals will help you keep track of your position on the sectional during flight. Some individuals prefer five or ten nm intervals for tick marks, while others prefer two or four nm intervals. Four nautical mile spacing works well for aircraft that operate at approximately 120 knots. Since the 120-knot airplane travels two nm every minute, each four nm tick mark represents approximately two minutes of flight time. This will become more significant when you study navigational methods in later paragraphs. On the example chart, you have tick marks on the right side of the course line at four nm intervals. If the search airplane has an airspeed indicator marked in miles per hour instead of knots, it may be advantageous to space the tick marks in statute mile intervals.

On the left side of the course line you have more tick marks, at five nm intervals, but measured backward from the destination. In flight, these continuously indicate distance remaining to the destination. If your navaids are operable, particularly the GPS, these marks are not necessary. Later in this chapter you will learn how to use navaids to continuously confirm remaining distance.

The next step in preparing the chart is to identify "*checkpoints*" along the course that you can later use to check not only your position on or off course, but the timing along the leg. Prominent features that will be easily seen from the air make the best checkpoints, and many fliers like to circle them or highlight them with a marker in advance. On the example, you might expect to see the large towers east of Oxford about three nm to your right shortly after take off, and expect later to see the town of Cornersville. Shortly thereafter, you expect to see the road and railroad bend east of Hickory Flat, followed by the Ripley Airport itself. In the example, the checkpoints are widely spaced, but on actual missions checkpoint spacing will be controlled by search altitude, weather conditions and visibility at the time of the flight.

MOA NAME	ALTITUDE OF USE	TIME OF USE	CONTROLLING AGENCY
ANNE HIGH	7,000	SR - SS MON - FRI	ZFW CNTR
BIRMINGHAM	10,000	0700-2200	ZTL CNTR
COLUMBUS 1, 2, & 3	8,000	SR - SS MON - FRI	ZME CNTR
MERIDIAN 1 EAST	8,000	SR - SS MON - FRI	ZME CNTR

Altitudes indicate floor of MOA. All MOAs extend to but do not include FL180 unless otherwise indicated in tabulation or on chart.

Figure 7-19

Other information that may be written on the chart includes estimated times of arrival (ETAs) at each checkpoint and reminders like "check gas," "switch tanks," or "contact mission base." Crew members are likely to spend less time "fishing" about the cockpit trying to find information in flight if it is already written on the chart.

7.8.1 Plotting the Course

Lay the chart on a table or other flat surface, and draw a straight line from your point of departure to the destination (airport to airport). This can be done with a plain ruler or, better, with a navigation plotter. Mark off the distance in ten or 20-mile intervals. Use a sharp pencil, making sure the line is straight and that it intersects the center of the airport symbol. Make a careful study of the intervening country and decide whether to fly direct or whether a detour may be desirable in order to avoid flying over large bodies of water, mountains, or other hazardous terrain. Note whether landing fields are available enroute for refueling or use in case of an emergency. Using an appropriate groundspeed and the actual distance to destination, estimate your time enroute. You should know the range (in fuel hours) of the aircraft you intend to fly. From this you can determine whether or not you can make the flight without fueling stops. Be sure to allow at least a 30-minute fuel reserve to your destination (this reserve is increased to 45 minutes for night flight).

7.8.2 Checkpoints

Now that you have established a definite course from departure to destination, study the terrain on the chart and choose suitable checkpoints. These should be distinctive features such as railroad tracks or highways, sharp bends in rivers, race tracks, towers, quarries, or lakes. As your flight progresses, these checkpoints will be used to maintain the correct course and to estimate the groundspeed. Your checkpoints need not be on your direct line of flight, but should be near enough to be easily seen. For this part of the pre-flight planning it is essential that you know the chart symbols (explained on the back of the chart) in order to recognize the many landmarks available as checkpoints.

You need to note the identifiers (i.e., airports, VORs, or airway intersections) along or near the route for entry into the GPS. If none (or not enough) are available, determine the latitude and longitude of suitable points along the route. The identifiers and lat/long points are used to enter a flight plan into the GPS and also serve as checkpoints that can be verified using the GPS during the flight.

7.8.3 Enclosing the Course

Another method you may use if your GPS is not operable is enclosing the course. This consists of using an easily recognizable feature on the terrain that lies parallel to your course. It may serve as a guideline or bracket, and may be a river, railroad track, electrical distribution lines, or a prominent highway. The ideal arrangement would be to have a continuous guideline on each side of the route, say five to ten miles from the line of flight. It is seldom that two can be found, but one will usually serve. If you should temporarily lose your checkpoints, you can fly to this chosen guideline and reset your course. Another landmark should be used as an end-of-course checkpoint to prevent flying beyond your destination.

7.8.4 True Course

Having plotted your course and made an accurate listing of checkpoints and the distances between them, measure the true course counting clockwise from true north. Use the meridian (north-south) line approximately midway between departure and destination. Your true course can be measured with a common protractor, or better still with a navigation plotter.

Without a GPS it's not likely that your aircraft will easily follow the precise true course between departure point and destination. Magnetic variation, wind and compass deviation affect the aircraft's ground track. The following sections discuss these factors and what the aircrew can do to counteract them if the GPS is not operable.

7.8.5 Applying Variation to True Course

The magnetic compasses used in aircraft refer all directions to magnetic north rather than to true north, which is the reference for directional measurement on the chart. At most places in the world, magnetic and true north do not coincide. This difference between magnetic variation at any locality is shown on all aeronautical charts by means of lines of equal variation known as isogonic lines. In the northeastern U. S. the variation is westerly (that is, the magnetic compass points west of true north) and the rest of the country is easterly (that is, the magnetic compass points east of true north). The dividing line between easterly and westerly variation is the agonic line, or line of no variation, where magnetic north and true north are the same.

Since we measure courses from a chart with reference to true north and then try to fly this course by means of a magnetic compass, it is necessary to apply the variation to the true course to determine magnetic course. To convert a true course to magnetic course, always add westerly variation and subtract easterly variation.

For example, say you plan to fly from Airport A to Airport B. The true course is 130°. The variation as shown on the chart by the nearest isogonic line is 12° east (12° E). Applying the rule of subtracting easterly variation and adding westerly variation, the magnetic course is 130° - 12° = 118°.

7.8.6 Applying wind correction

Assume that you have climbed to cruising altitude and arrived over your first checkpoint. Between this checkpoint and the second one, you should make allowance for the approximate drift of your aircraft due to the effect of the wind. In pilotage, correction for wind drift is made by noting whether or not your plane is drifting to the right or left of your intended true course. Should you note a right drift it will be necessary to correct to the left. The amount of correction will be determined by the amount of observed drift and where you actually are in relation to your intended course. If you note an approximate 10-degree leftward drift after passing over your first checkpoint, it will be necessary to correct 10 degrees to the right in order to remain on course. Drift of the airplane can be observed if you note landmarks such as a highway, railroad, or section lines approximately parallel to your course. In flying one of these lines the plane's drift to right or left can be approximated.

It is important that between the first and second checkpoints you have noted the reading on your compass. The compass (assuming no instrument error) should now read the sum of your true course, plus or minus variation, and plus or minus your wind correction angle. This is the magnetic heading, and should be maintained on your compass from one checkpoint to another so long as you remain on course.

In the example problem stated above, the computations for magnetic heading should be:

- True course (TC) = 130°
- Magnetic variation (VAR) = 12° E
- Magnetic course (MC) = 118°
- Wind correction angle (WCA) = 10° R
- Magnetic heading (MH) = 128°

Thus you have a magnetic heading from first to second checkpoint. You would hold this magnetic heading of 128 so long as you remain on course toward the next checkpoint.

If your calculations are correct, your estimate of the drift angle is close enough, and you hold the magnetic heading of 128 degrees, then you will actually make good the true course of 130 degrees between Airport A and Airport B. Remember that in correcting your compass for variation and wind effect, you are simply setting up a compass reading calculated to keep you on your intended true course.

7.8.7 Compass Deviation

Compass deviation is technically defined as the angle between the magnetic meridian and the axis of a compass card, expressed in degrees east or west (in the same way that variation is) to indicate the direction in which the northern end of the compass is offset from magnetic north. Less technically, deviation is compass error. It is caused by a number of things, but mostly by instruments and equipment within the aircraft itself - metal parts of the aircraft structure, flashlights, cockpit heaters, electrical circuits, radios, metal tools, cigarette lighters. Even a Boy Scout's pocket compass, when placed close enough, can throw an aircraft compass off as much as 50 degrees. The point is, however, that the error in a compass caused by the permanent equipment in an aircraft is not important if the amount of error is known. Some error can be removed by qualified instrument mechanics adjusting the compass magnets. This is called compass compensation. To determine the amount of error left after compensation, the compass can be "swung."

The aircraft is placed in straight and level flight attitude in the center of a large circle oriented exactly to magnetic north and usually painted on the ramp or parking apron of an airport. Sometimes the aircraft engine is started up and the radio equipment is turned on to simulate as closely as possible actual flight conditions. The aircraft is then turned within the circle until it is aligned with magnetic north, and the difference between the reading of the aircraft compass and magnetic is the deviation for that heading. The process is repeated every 30 degrees around the compass rose. A record of the deviation is made on each of the 12 headings, and is then entered on a compass correction card that is placed near the compass installation in the cockpit for the pilot's reference.

7.9 Navigational Methods

With the advent of GPS, most VFR navigation is simply a matter of entering your waypoint and/or destination into the GPS and flying the displayed heading. However, other methods of navigation will be reviewed before we discuss how to use the GPS for navigation.

7.9.1 Dead Reckoning and Pilotage

The most commonly used methods of navigating without using navaids are *pilotage*, *dead reckoning*, and a combination of both. This section will cover the advantages and disadvantages of each.

Pilotage is nothing more than basic map reading, proceeding from one prominent landmark to another. You could conceivably use pilotage to navigate from New York City all the way to Miami if you were to simply fly to the coast, turn right, and then follow the shoreline, while periodically checking your position against prominent coastal features and cities. Given a chart with sufficient detail, you can do the same with smaller features and landmarks. Its greatest disadvantage is that there may not always be prominent landmarks directly in line with the direction you wish to fly. On the hypothetical Oxford-to-Ripley flight, there aren't many landmarks nearby in the first ten miles. If the visibility is good, you might see the 999' and 1100' towers east of Oxford to your right, but initially not much more, especially if you're at low altitude.

Dead reckoning is a technique of using speed and time to calculate distance, and then plotting the calculated distance in the direction the aircraft has been traveling. The process is frequently referred to as *time, distance, and heading*. As an example of dead reckoning, if you take off from Oxford and fly a 050° magnetic heading for 16 1/2 minutes at 120 knots, and then look down, you would be over or very near the Ripley Airport. Dead reckoning becomes more complicated when wind is present, and *by itself* usually does not render the level of accuracy required to fly precise search patterns.

Most experienced aviators continuously use a combination of pilotage and dead reckoning when visually navigating, alternating from one to the other so frequently that it appears to be a singular process, not an actual choice of alternatives. For flight segments that don't have a wealth of landmarks, like northeast of Oxford, dead reckoning helps estimate aircraft position, until you can confirm it (through pilotage) at or near a landmark. In this sense, you use pilotage to verify the dead reckoning, but the reverse can be true. Again, proceeding 050° from Oxford, if you pass a town approximately 8 minutes after take off, is it Cornersville or Hickory Flat? On the chart, both towns appear similar, and they're along hard-surfaced roads that generally run northwest to southeast. Since you've only been airborne for 8 minutes, and you're flying at 120 knots, the town *can't* be Hickory Flat which is 23 miles away. The plane would have to fly nearly three miles a minute or almost 180 knots to fly 23 miles in eight minutes.

Good pilotage also has the capability to improve your dead reckoning by indirectly providing you with more accurate information. Returning to the example, if you pass Cornersville 10 minutes after take off instead of 8 minutes as planned, the average ground speed for those 10 minutes is 102 knots, not the 120 knots you had planned. Thus, you should not expect to pass Hickory Flat, 6 1/2 miles further, for another 4 minutes, and will not arrive at Ripley until 19 minutes after take off, not 16 minutes as you had originally planned. You could rightfully estimate an approximate 18-knot headwind en route to Ripley and might expect an 18-knot tailwind, a 138-knot ground speed, and a 14-minute en route time for the opposite-direction flight back to Oxford.

Pilotage in its simplest form is a means of navigating from one point to another by visual reference to landmarks or checkpoints on the ground. These may be railroad tracks, highways, cities, towns, rivers, mountains, shorelines, dams, racetracks, or any of the scores of other prominent features on the earth's surface which can be seen and identified from the air. All that's required for this basic kind of navigation is good visibility, an up-to-date chart, and an ability to organize your procedures in a systematic way. It sounds easy, and it actually is -- if you don't try to fly in doubtful weather and if you plan your flight.

Experienced pilots place a lot of emphasis on pre-takeoff planning for a cross-country flight. Planning is, in fact, an integral part of cross-country flying.

7.9.2 Low Level Flying

The closer to the ground you are, the less time you have to observe landmarks and make visual observations. Remember also that as you get closer to the ground, you have less time to see and avoid obstructions and hazards. You should study the map of the area you will encounter in great detail so that you know what ground references, obstructions and hazards to expect and so that you will be able to quickly identify them in flight. Crew coordination will be essential at low levels, so ask questions during the aircrew briefing. Finally, due to the increased concentration and quicker pace of low-level flying, you will find that fatigue sets in more quickly -- so plan accordingly.

7.9.3 GPS Navigation

The advent of the Global Positioning System (GPS) and its incorporation into CAP aircraft panels marks a significant improvement in the ease and accuracy of navigation. GPS allows us to fly much more precisely than in the past, thus increasing safety and fuel efficiency.

The GPS is a space-based radio positioning, navigation and time-transfer system based upon accurate and continuous knowledge of the spatial position of each satellite in the system with respect to time and distance from a GPS receiver. The GPS receiver automatically selects appropriate signals from the satellites in view and translates these into a three-dimensional display of position, velocity and time. System accuracy for civilian (and CAP) users is normally 100 meters horizontally.

7.9.3.1 How does GPS make navigation easier?

GPS allows us to fly to a point, or between any two points, with incredible ease and accuracy. It enables us to know precisely where we are at all times. Therefore, both the crew and the mission staff know that transit times will be minimized, search times will be maximized, search effectiveness will be increased, crew efficiency will be increased, fuel efficiency will be increased, and flight safety will be enhanced.

The benefits of being able to plan and fly directly to and from a point, and to precisely fly between any two points without reference to landmarks, are obvious. Transit times go down, routes are flown as they are planned, obstructions and hazardous terrain can be avoided, airspace “busts” can be avoided, and the aircrew spends less time scouring charts and ground references to determine aircraft position.

Additionally, the ability to be certain that a crew is flying the route as planned increases safety when more than one aircraft is in route to the search area at the same time.

7.9.3.2 How do we use GPS for navigation?

The database in the GPS receiver contains the locations of every public-use and military airport, VOR, and airway intersection in the United States. Any of these airports, VORs, and intersections can be selected as a destination or as a waypoint on a flight plan. If you aren't flying to an airport or VOR, you can define your own waypoint and enter it into the database.

Since GPS manufacturers differ somewhat in the way information is entered and displayed on their units, we won't go into detail on how to enter or display information. However, since all GPS units have essentially the same capabilities and displays, we can provide a generic description of the GPS. Each of you must study your aircraft's GPS manual and become thoroughly familiar with its capabilities and operation.

In order to fly directly to a point you must enter its identifier (e.g., 'AMA' for Amarillo International Airport or 'PNH' for the Panhandle VORTAC, for a flight to Amarillo, Texas). The GPS requires you to select whether the point is an airport, a VOR, an airway intersection, or a user-defined waypoint and then you manually enter its name and select it. The GPS then displays data pertinent to the destination or waypoint.

If you're not flying to an airport, VOR, or airway intersection you can define your own waypoint, called a "user-defined" waypoint. You enter the latitude and longitude of the waypoint and give it a name. You then select it as described above. Most GPS databases allow you to store 300 or more of these user-defined waypoints, and they remain in the database until you delete them.

The GPS navigation page will display the heading to your destination or waypoint along with the aircraft's track over the ground. By keeping track-over-ground the same as the heading, you will be correcting for any wind and be flying directly to your destination or waypoint. The GPS also displays a Course Deviation Indicator (CDI) on the same page, and by keeping the CDI centered you will be flying directly to your destination.

The GPS continuously updates the distance from and the time remaining to your destination or waypoint (ETE). It also tracks the airports and VORs nearest to your route (usually ten or more within 50 nm). These airports and VORs can be displayed at the touch of a button.

Another mode of the GPS, usually called the Auxiliary mode, displays and continuously updates your current position in terms of latitude and longitude. This feature is particularly useful in flying search patterns (discussed later), and provides another means for you to determine where you are on a sectional or other map. It is also useful in reporting your position to mission base or ground units.

The GPS also enables you to enter a flight plan. You enter each waypoint (leg) in its proper sequence, name the flight plan, and then activate it at the beginning of your flight. The GPS automatically displays the current leg, rolls over to the next leg when a waypoint is reached, and continues in this manner until you reach your final destination.

Most GPS units also warn you when you near controlled and special use airspace.

All these features greatly enhance situational awareness and safety, especially for night flights. You can always find your present position, and in case of trouble you can select the nearest airport and the GPS will display heading and distance to that airport.

As an observer, you should be able to:

assist the pilot in planning a flight where GPS will be used for navigation.

select/display an airport, VOR, or intersection.

enter a user-defined waypoint (lat/long), name it, and select it.

select/display present position (lat/long).

display the nearest airports, and determine their heading and distance.

display the nearest VORs, and determine their heading and distance.

use GPS displays to determine your position on a sectional or other map.

NOTE:

However convenient and accurate, you cannot let GPS become your sole means of navigation and situational awareness! The GPS will not automatically guide you around or over obstructions and other hazards. You still need to thoroughly plan your flight and then periodically verify your position using other navaids (e.g., VOR and DME). You still need to track your position on the sectional.

Although GPS displays altitude, it is subject to error. The altimeter is your primary instrument for altitude.

Also, remember that CAP does not have IFR-certified GPS units. Our GPS units cannot be used for GPS instrument approaches.

7.10 Standardized Grid Systems

A grid is a network of regularly spaced horizontal and vertical lines used to help quickly locate points on a map. Most city street maps have grid systems that help motorists locate streets or other points of interest. A commonly used grid system on city street maps involves numerical and alphabetical references. Regularly spaced letters may be printed across the top of such a map designating imaginary vertical columns, while regularly spaced numbers are printed down the sides of the map designating imaginary horizontal rows. If you want to find Maple Street and the map directory indicates Maple Street is located in section K-5, you then look at or near the intersection of column K with row 5. Within that area, you should find Maple Street.

The Civil Air Patrol has found it useful to construct similar grid systems on aeronautical charts for search and rescue operations. Some maps, like city maps, already have grid systems constructed on them, but aeronautical charts typically do not. You can construct a grid system on any type of chart or map. You may use numbers and letters like street maps, or you could use only numbers. In either case, the system should give *every* user a common, standardized method for identifying a location according to its position within the grid. It is very easy to exchange location information over the radio using the grid system. With the known grid positions, other team members can quickly determine on their own charts the location of a sighting or point of interest.

Grid systems are especially helpful when locating a position that has no nearby distinguishable landmarks or features, such as buildings, roads, or lakes. Grid systems will work anywhere, even in the middle of large lakes, in deep woods, or in swamps.

Anyone can develop a workable system provided that all members of the search team use the same grid system.

7.10.1 Sectional Chart Grids

The Civil Air Patrol has adopted a standard grid system built upon the matrix of parallels of latitude and meridians of longitude and the sectional aeronautical chart. Sectional charts cover a land area approximately seven degrees of longitude in width and four degrees of latitude in height. Figure 7-20 shows the latitude and longitude boundaries of each sectional chart. The St. Louis chart, for example, covers an area that is bounded by the following latitudes and longitudes: 40° 00’ N (north boundary), 36° 00’ N (south boundary), 91°-00’ W (west boundary), and 84°-00’ W (east boundary).

The sectional grid system used by Civil Air Patrol divides each sectional’s area into 448 smaller squares. This process begins by dividing the whole area into 28 *1-degree* grids, using whole degrees of latitude and longitude as shown in Figure 7-21. Then each one-degree grid is divided into four 30-minute grids, using the 30-minute latitude and longitude lines as shown in Figure 7-22. Finally, each of the 30-minute grids is divided into four *15-minute* grids (the standard), using the 15- and 45-minute latitude and longitude lines as shown in Figure 7-23.

Chart	Identifier	North Grid Limit	South Grid Limit	West Grid Limit	East Grid Limit	Total Grids
Seattle	SEA	49-00N	44-30N	125-00W	117.00W	576
Great Falls	GTF	49-00N	44-30N	117-00W	109-00W	576
Billings	BIL	49-00N	44-30N	109-00W	101-00W	576
Twin Cities	MSP	49-00N	44-30N	101-00W	93-00W	576
Green Bay	GRB	48-15N	44-00N	93-00W	85-00W	544
Lake Huron	LHN	48-00N	44-00N	85-00W	77-00W	512
Montreal	MON	48-00N	44-00N	77-00W	69-00W	512
Halifax	HFX	48-00N	44-00N	69-00W	61-00W	512

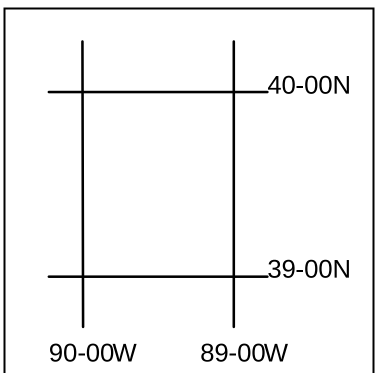


Figure 7-21

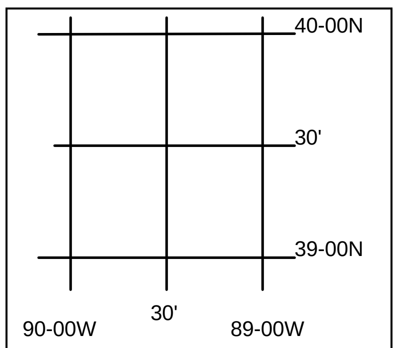


Figure 7-22

Klamath Falls	LMT	44-30N	40-00N	125-00W	117-00W	576
Salt Lake City	SLC	44-30N	40-00N	117-00W	109-00W	576
Cheyenne	CYS	44-30N	40-00N	109-00W	101-00W	576
Omaha	OMA	44-30N	40-00N	101-00W	93-00W	576
Chicago	ORD	44-00N	40-00N	93-00W	85-00W	512
Detroit	DET	44-00N	40-00N	85-00W	77-00W	512
New York	NYC	44-00N	40-00N	77-00W	69-00W	512
San Francisco	SFO	40-00N	36-00N	125-00W	118-00W	448
Las Vegas	LAS	40-00N	35-45N	118-00W	111-00W	476
Denver	DEN	40-00N	35-45N	111-00W	104-00W	476
Wichita	ICT	40-00N	36-00N	104-00W	97-00W	448
Kansas City	MKC	40-00N	36-00N	97-00W	90-00W	448
St. Louis	STL	40-00N	36-00N	91-00W	84-00W	448
Cincinnati	CVG	40-00N	36-00N	85-00W	78-00W	448
Washington	DCA	40-00N	36-00N	79-00W	72-00W	448
Los Angeles	LAX	36-00N	32-00N	121-30W	115-00W	416
Phoenix	PHX	35-45N	31-15N	116-00W	109-00W	504
Albuquerque	ABQ	36-00N	32-00N	109-00W	102-00W	448
Dallas-Fort Worth	DFW	36-00N	32-00N	102-00W	95-00W	448
Memphis	MEM	36-00N	32-00N	95-00W	88-00W	448
Atlanta	ATL	36-00N	32-00N	88-00W	81-00W	448
Charlotte	CLT	36-00N	32-00N	81-00W	75-00W	384
El Paso	ELP	32-00N	28-00N	109-00N	103-00W	384
San Antonio	SAT	32-00N	28-00N	103-00W	97-00W	384
Houston	HOU	32-00N	28-00N	97-00W	91-00W	384
New Orleans	MSY	32-00N	28-00N	91-00W	85-00W	384
Jacksonville	JAX	32-00N	28-00N	85-00W	79-00W	384
Brownsville	BRO	28-00N	24-00N	103-00W	97-00W	384
Miami	MIA	28-00N	24-00N	83-00W	77-00W	384

Figure 7-20

Next, the grid squares are numbered 1 through 448, beginning usually with the most northwest square on the entire sectional and continuing straight east through number 28. The numbering resumes in the second row, with number 29 placed beneath number 1, 30 beneath 2, and so on through 56. The third row begins with number 57 beneath numbers 1 and 29, and continues through 84. Numbering continues through successive rows until all 448 squares have a number.

In Figure 7-23, each 15-minute grid square has the number it would have received if this demonstration had started with the entire St. Louis sectional chart. Figure 7-24 represents the division of the whole St. Louis sectional into 15-minute grids, with respective grid numbers assigned. To conserve space Figure 7-24 doesn't include the area between 85°W longitude and 89°30'W longitude

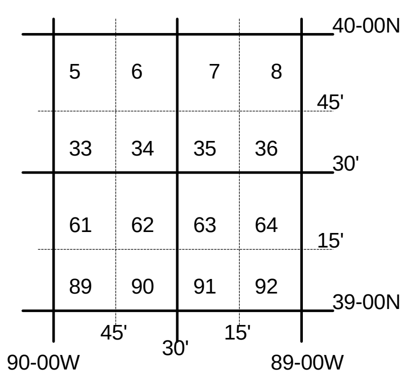


Figure 7-23

Returning to Figure 7-20, notice that the eastern limit of the Kansas City sectional grid, 90° 00'W, is one full degree of longitude east of the western limit of the St. Louis sectional, 91° 00' W. The two sectionals overlap by one full degree of longitude. When drawing a grid over this overlap area, which numbers would you assign to these grid squares, the Kansas City or St. Louis grid numbering?

40-00N	91-00W					90-00W				85-00W		
	MKC 25	MKC 26	MKC 27	MKC 28	STL 5	STL 6	< >	< >	STL 25	STL 26	STL 27	STL 28
	MKC 53	MKC 54	MKC 55	MKC 56	STL 33	STL 34	< >	< >	STL 53	STL 54	STL 55	STL 56
	MKC 81	MKC 82	MKC 83	MKC 84	STL 61	STL 62	< >	< >	STL 81	STL 82	STL 83	STL 84
39-00N	MKC 109	MKC 110	MKC 111	MKC 112	STL 89	STL 90	< >	< >	STL 109	STL 110	STL 111	STL 112
	MKC 137	MKC 138	MKC 139	MKC 140	STL 117	STL 118	< >	< >	STL 137	STL 138	STL 139	STL 140
	MKC 165	MKC 166	MKC 167	MKC 168	STL 145	STL 146	< >	< >	STL 165	STL 166	STL 167	STL 168
	MKC 193	MKC 194	MKC 195	MKC 196	STL 173	STL 174	< >	< >	STL 193>	STL 194	STL 195	STL 196
38-00N	MKC 221	MKC 222	MKC 223	MKC 224	STL 201	STL 202	< >	< >	STL 221	STL 222	STL 223	STL 224
	MKC 249	MKC 250	MKC 251	MKC 252	STL 229	STL 230	< >	< >	STL 249	STL 250	STL 251	STL 252
	MKC 277	MKC 278	MKC 279	MKC 280	STL 257	STL 258	< >	< >	STL 277	STL 278	STL 279	STL 280
	MKC 305	MKC 306	MKC 307	MKC 308	STL 285	STL 286	< >	< >	STL 305	STL 306	STL 307	STL 308
37-00N	MKC 333	MKC 334	MKC 335	MKC 336	STL 313	STL 314	< >	< >	STL 333	STL 333	STL 334	STL 336

Figure 7-24

In cases where two sectionals overlap one another, the Civil Air Patrol always uses the numbering system for the western-most chart of the two in question. You can see this in Figure 7-24, where the overlap area between 90° 00’ and 91° 00’, shown in the first 4 vertical columns, is identified with Kansas City (MKC) grid numbering, not St. Louis. Note too that, since the Kansas City grid numbering is used in this overlap area, the first 4 columns of the St. Louis grid numbering system are omitted. Several other such overlaps exist within the grid system.

Table A-15-1 in CAPM 50-15 tells you how many grids are in each sectional. If the table is not available you can compute it using the grid limits. Take the difference in the northern and southern grid limits and multiply by 4 (1/4 degree x 4 to make 1 degree.) Do the same for the east and west grid limits. Then multiply the two products to get the total number of grids on your sectional. For example, the St. Louis sectional extends 4° from 40°-00’ N to 36°-00’ N. Each degree will contain 4 grids, so there will be 4 x 4 = 16 rows of grids. The sectional extends east/west for 7° from 91°-00’ W - 84°-00’ W, so there will be 7 x 4 = 28 columns of grids. Therefore, the total number of grids on the chart is 16 x 28 = 448. Remember some sectionals don't start counting at 1 because of overlap with an adjacent sectional. If your sectional does this you need to memorize the first grid number:

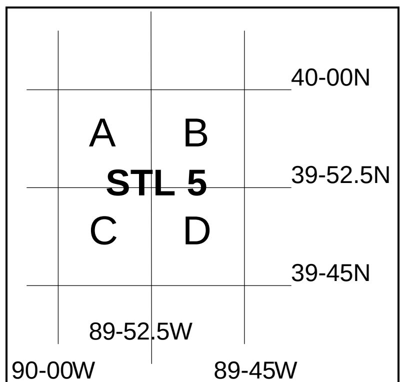


Figure 7-25

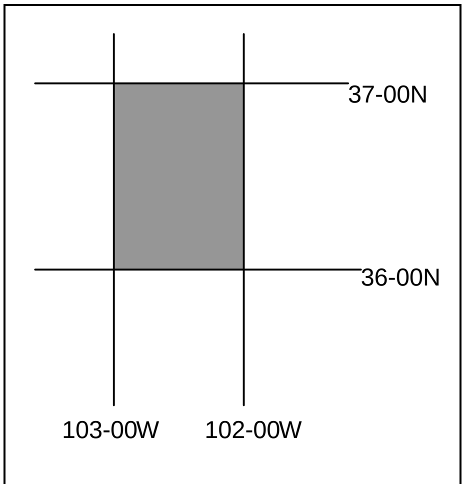


Figure 7-26

When circumstances require, a 15-minute grid is divided into four quadrants using 7 1/2 degree increments of latitude and longitude, creating four equal size grids that are approximately 7 1/2 miles square. The quadrants are then identify alphabetically - A through D - starting with the northwest quadrant as A, northeast as B, southwest as C and southeast as D, as in Figure 7-25. A search area assignment in the southeast quadrant may then be made as, "Search STL 5D."

Pinpointing an area within the grid system becomes easy once you gain familiarity with the grids many uses. You soon will be able to quickly plot any area on a map and then fly to it using the basic navigation techniques already discussed.

7.11 Standardized Lat/Long Grid System

Another means of designating a grid system is the Standardized Latitude and Longitude Grid System. It has an advantage over the sectional standardized grid in that it can be used on any kind of chart that has lines of latitude and longitude already marked. In this system, 1-degree blocks are identified by the intersection of whole numbers of latitude and longitude, such as N36-00 and W102-00. These points are always designated with the latitude first, such as 36/102, and they identify the area north and west of the intersection of these two lines. In Figure 7-26, section 36/102 is identified by the gray shading.

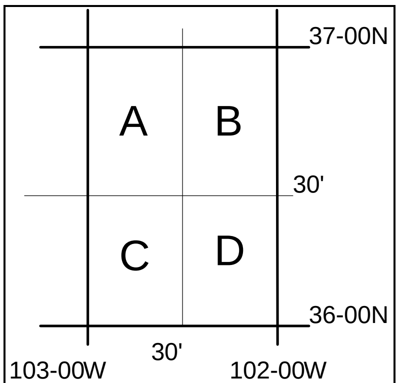


Figure 7-27

Next, the one-degree grid is divided into four quadrants using the 30-minute lines of latitude and longitude. Label each quadrant A through D; the northwest quadrant being 36/102A, the northeast 36/102B, the southwest 36/102C, and the southeast 36/102D, as shown in Figure 7-27. Each quadrant can also be divided into four sub-quadrants, labeled AA, AB, AC, and AD, again starting with the most northwest and proceeding clockwise, as shown in Figure 7-28. This grid system works on any chart that has latitudes and longitudes printed on it.

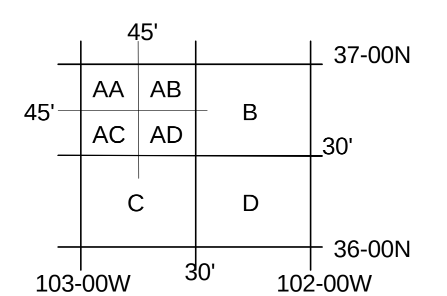


Figure 7-28